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ON THE RELATION OF A CONTINUOUS CURVE TO ITS COMPLEMENTARY DOMAINS IN SPACE OF THREE DIMENSIONS[1]

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Schoenflies has shown[2] that, in order that a closed, bounded and connected point-set, lying in a *plane* S, should be a continuous curve, it is necessary and sufficient that (1) if R is a domain complementary to M, every point of the boundary of R should be "accessible from all sides" with respect to R, and (2) if ϵ is any preassigned positive number, there do not exist infinitely many distinct domains, complementary[3] to M, and all of diameter[4] greater than ϵ. In the present paper I will exhibit examples of continuous curves, in *space of three dimensions*, which satisfy neither of these conditions.

If, in a *plane* S, a closed and bounded point-set K separates S into just two domains, S_1 and S_2, such that every point of K is a limit point both of S_1 and of S_2, then, in order that K should be a simple closed curve, it is[5] necessary and sufficient that every point of K should be accessible[6] from every point which does not belong to K. In this paper it will be shown that, for a space S of *three dimensions*, this condition is neither necessary nor sufficient in order that K should be a simple closed surface or in order that it should be a continuous curve. It will be shown, however, that a closed, bounded and connected point-set in space of three dimensions is a continuous curve provided it is the common boundary of two mutually exclusive domains both of which are *uniformly connected im kleinen*.[7]

1. *There exists, in a three dimensional space S, a continuous curve M which divides S into just two domains, S_1 and S_2, such that (a) the boundary of S_1 contains a point which is not accessible from any point of S_1, (b) the domain S_2 is uniformly connected im kleinen, (c) the boundary of S_1 is not a continuous curve.*

Example.—Let K denote a cube placed so that b, one of its bases, is horizontal. Let l and f denote two opposite lateral faces of K. Let

$ABCD$ and $EFGH$ denote two squares concentric with l and lying within it and such that $EFGH$ is within $ABCD$, AB and EF being horizontal. Let I and J denote points in the face f such that the planes IAB and JCD are parallel to b and such that I is equidistant from A and B, while J is equidistant from C and D. We thus have a right prism whose triangular bases are ABI and DCJ. Let P denote this prism and let Q denote the right pyramid whose base is the square $EFGH$ and whose apex is at O, a point half-way between I and J. For each positive integer n, let α_n denote a plane parallel to f and at a distance from f equal to a/n, where a is one-half the length of a side of K. For each n, let β_n denote a plane parallel to, and half-way between the planes α_n and α_{n+1}. Let I_n denote that portion of the interior of P which is intercepted between the planes α_n and β_n. Let R denote the interior of the pyramid Q. Let S_1 denote the point-set composed of R together with the sets $I_1, I_2, I_3, I_4, \ldots$. Let N denote the point-set composed of the surface of K together with its interior and let M denote N-R. The set M is a continuous curve, S_1 is one of its complementary domains, and the straight line interval JI is a portion of the boundary of S_1. But no point of JI, except O, is accessible from any point of S_1. The boundary of S_1 is not connected *im kleinen* at any point of JI except O. Clearly S_2, the exterior of the cube K, is uniformly connected *im kleinen*.

2. *If ϵ is any preassigned positive number, there exists a continuous curve M such that there are infinitely many distinct domains, complementary to M and all of diameter greater than ϵ.*

Example.—Consider again the cube K and the domains $I_1, I_2, I_3, \ldots$ of Example 1, it being understood that the distance between the planes IAB and JCD of that example is 2ϵ. Let M denote the point-set $N-(I_1+I_2+I_3+\ldots)$ where N has the same meaning as in Example 1. Here M is a continuous curve and each I_n is one of its complementary domains.

3. *There exists, in three dimensional space, a continuous curve M which divides space into just two domains, S_1 and S_2, such that (a) every point of M is a limit point both of S_1 and of S_2, (b) not every point of M is accessible from a point of S_2.*

Example.—Let K denote a square whose vertices A, B, C, D are the points $(0, -1, -1)$, $(0, 1, -1)$, $(0, 1, 1)$ and $(0, -1, 1)$, respectively. For each integer n (positive or negative) let K_n denote a square whose vertices, A_n, B_n, C_n, D_n, are the points $(1/n, -1, -1)$, $(1/n, 1, -1)$, $(1/n, 1, 1)$ and $(1/n, -1, 1)$, respectively. For each n let $\overline{K}_n$ denote a square whose vertices, $\overline{A}_n$, $\overline{B}_n$, $\overline{C}_n$, $\overline{D}_n$, are so situated that $\overline{A}_n$ is half-way between A_n and A_{n_1}, $\overline{B}_n$ is half-way between B_n and B_{n_1}, $\overline{C}_n$ is half-way between C_n and C_{n_1} and $\overline{D}_n$ is half-way between D_n and D_{n_1}, where n_1 denotes $n+1$ or $n-1$ according as n is positive or negative. For every integer n and every pair of integers i and j which are numerically less

than $4^{|n|}$, let $\overline{P}_{ijn}$ denote that point, within the square $\overline{K}_n$, whose y and z are $i/4^{|n|}$ and $j/4^{|n|}$, respectively. For each n, let T_n denote the set of all points $[\overline{P}_{ijn}]$ for which i and j are even numbers numerically less than $4^{|n|}$ and let U_n denote the set of all points $[\overline{P}_{ijn}]$ such that i and j are odd numbers numerically less than $4^{|n|}$. For every point $\overline{P}_{ijn}$ belonging to T_n or to U_n let $\overline{K}_{ijn}$ denote a circle lying in the plane $\overline{K}_n$, with center at $\overline{P}_{ijn}$ and with a radius equal to $1/4^{|n|+2}$. Thus with each point of the set $T_n + U_n$ there is associated a definite circle having that point as center, and every one of these circles lies wholly without every other one. Now let P'_{ijn} and K'_{ijn} denote the orthogonal projections of P_{ijn} and $\overline{K}_{ijn}$, respectively, onto the plane of the square K_{n_1} and let P_{ijn} denote the orthogonal projection of $\overline{P}_{ijn}$ onto the plane of K_n. For each point $\overline{P}_{ijn}$ belonging to the set T_n let S_{ijn} denote the right circular cylinder whose bases have the circles $\overline{K}_{ijn}$ and K'_{ijn} as their perimeters, and for each point $\overline{P}_{ijn}$ belonging to U_n let C_{ijn} denote the right circular cone whose base has $\overline{K}_{ijn}$ as its perimeter and whose apex is the point P_{ijn}. It is to be noted that S_{ijn} exists only when i and j are even and that C_{ijn} exists only when i and j are odd. For each n, let P_n denote the right parallelopiped which has K_n and $\overline{K}_n$ as opposite lateral faces and let R_n denote the interior of P_n. Let I_n denote that portion of R_n which remains after the removal of every point of R_n which lies either within, or on the surface of any C_{ijn} (i and j odd). For each n let L_n denote the point-set obtained by adding to I_n the interiors of all the cylinders S_{ijn} (i and j even) together with the interiors of the bases of these cylinders. Let K^* denote a rectangle lying in the plane $z=2$ and with sides equal and parallel to the respective sides of the upper base of P_1. Let P' denote a parallelopiped whose upper base is K^* and whose lower base is the upper base of P_1. Let P'' denote a parallelopiped whose upper base is K^* and whose lower base is the upper base of P_{-1}. Let L^* denote the point-set composed of the interiors of P' and P'' and the interiors of the upper bases of P_1 and P_{-1}. Let H denote the point-set $L^* + L_1 + L_2 + L_3 + \ldots$, and let M denote its boundary. The point-set H is a domain and M is a continuous curve which separates space into two domains S_1 and S_2 (where S_1 is H). Every point within the rectangle K belongs to M. But no point within this rectangle is accessible from any point in S_2, though every point of M is a limit point both of S_1 and of S_2. Neither S_1 nor S_2 is uniformly connected *im kleinen*.

4. *There exists, in a space S of three dimensions, a closed, connected and bounded point-set M which divides S into just two domains such that (a) both of these domains are uniformly connected im kleinen, and every point of M is accessible from one of these domains, but (b) M is not a continuous curve.*

Example.—Let K denote the cube which is bounded by the planes $x=0$,

$x=2, y=0, y=2, z=0, z=2$. For each positive integer n let A_n denote the point $(1/n, 1/n, 0)$ and let B_n denote the point $(1/n, 1/n, 2)$. Let M denote the point-set composed of the surface of K together with all the straight line intervals $A_1 B_1, A_2 B_2, A_3 B_3, \ldots$.

5. *There exists, in three dimensional space, a closed, bounded and connected point-set M which is not a continuous curve but which divides space into just two domains S_1 and S_2 such that (a) every point of M is accessible both from every point of S_1 and from every point of S_2, (b) the domain S_1* is uniformly connected *im kleinen.*

Example.—Returning to Example 3, let H denote a cube whose upper base lies in the plane $z=1$, whose center is at the point $(0, 0, -1)$, and one of whose faces is in the plane $x=2$. For every positive integer n, the upper base of the parallelopiped P_n of Example 3 is a part of the upper base of H but the remainder of P_n is wholly within H. Let R denote the set of points composed of (*a*) the exterior of H, (*b*) the interiors of the upper bases of the parallelopiped $P_1, P_2, P_3, \ldots$, (*c*) the interiors of $P_1, P_2, P_3, \ldots$ and (*d*) the interiors of those cylinders S_{ijn} (of Example 3) for which n is positive, together with the interiors of the bases of those cylinders. Let M denote the boundary of R. The point-set M is closed, connected and bounded and it divides space into just two domains, S_1 and S_2 (where S_1 is R), and furthermore every point of M is accessible from every point of S_1 and from every point of S_2. But M is not a continuous curve. It fails to be connected *im kleinen* at the point $(0, 0, 0)$. The domain S_1 is uniformly connected *im kleinen* but the domain S_2 is not.

THEOREM 1. *If, in a three dimensional space S, the closed, bounded and connected point-set M divides S into just two domains S_1 and S_2 such that (a) every point of M is a limit point both of S_1 and of S_2, and (b) both S_1 and S_2 are uniformly connected im kleinen; then M is a continuous curve.*

This theorem will be proved with the assistance of the following lemma. A proof of this lemma will be given elsewhere.

Lemma. *Suppose that, in space of three dimensions, (1) M is a closed point-set, (2) $A_1 B_1$ and $A_2 B_2$ are two simple continuous arcs each of which consists of a finite number of straight line intervals, (3) neither of the arcs $A_1 B_1$ and $A_2 B_2$ has a point in common with M, (4) every simple continuous arc which joins a point of $A_1 B_1$ to a point of $A_2 B_2$ contains at least one point of M. Then M contains a closed and connected point-set which contains at least one point in common with each of the straight line intervals $A_1 A_2$ and $B_1 B_2$ and has a diameter less than, or equal to, twice that of the point-set composed of the two arcs $A_1 B_1$ and $B_1 B_2$.*

Proof of Theorem 1.—Suppose, on the contrary, that M is not connected *im kleinen*. Then there exists a positive number ϵ and two infinite sequences of points $A_1, A_2, A_3, \ldots$ and $B_1, B_2, B_3, \ldots$, belonging to M, such that $\lim_{n=\infty} A_n B_n = 0$ and such that, for no n, do A_n and B_n lie together

in a closed and connected subset of M of diameter less than or equal to ϵ. But, since the domains S_1 and S_2 are uniformly connected *im kleinen*, there exists a positive number $\delta\epsilon$ such that if X and Y are two points both belonging to S_1, or both belonging to S_2, and such that $XY < \delta\epsilon$ then X and Y can be joined by a simple broken line of diameter less than $\epsilon/9$ which lies wholly in S_1 or wholly in S_2. There exists an integer m such that A_m, $B_m < \delta\epsilon/3$. For each positive integer n there exists spheres α_n and β_n, with centers at A_m and B_m, respectively, and with diameters less than each of the numbers $\delta\epsilon/3$, $\epsilon/9$ and $1/n$. There exist, within α_n, points E_n and E'_n belonging to S_1 and S_2, respectively, and within β_n, points D_n and D'_n belonging to S_1 and S_2, respectively. There exist broken lines $D_n E_n$ and $D'_n E'_n$ lying in S_1 and S_2, respectively, and with diameters less than $\epsilon/9$. Every simple continuous arc from a point of $D_n E_n$ to a point of $D'_n E'_n$ contains a point of M. It follows from the above lemma that M contains a closed and connected point-set M_n, of diameter less than or equal to $2\epsilon/3$, which contains a point within α_n and a point within β_n. The sequence of closed and connected point-sets $M_1, M_2, M_3, \ldots$ has, as its limiting set,[8] a closed and connected subset of M which contains both A_m and B_m and has a diameter less than ϵ. Thus the supposition that M is not connected *im kleinen* has led to a contradiction.

[1] Presented, in part, to The American Mathematical Society, October 29, 1921.

[2] Schoenflies, A., *Die Entwickelung der Lehre von den Punktmannigfaltigkeiten*, Zweiter Teil, Leipsig, 1908, p. 237.

[3] A connected set of points M lying in a space S of one or more dimensions is said to be a *domain* (with respect to S) provided there exists, in S, a closed (or vacuous) point-set N such that $M = S - N$. The domain R is said to be complementary to the closed point-set M if (1) R contains no point of M, and (2) the boundary of R is a subset of M.

[4] The diameter of a bounded point-set M is the smallest number d such that if X and Y are any two points of M then the distance from X to Y is less than d.

[5] Cf. Schoenflies, A., "Ueber einen grundlegenden Satz der Analysis Situs," *Göttingen, Nachr. Ges. Wiss.*, 1902 (185).

[6] A point X, belonging to a closed point-set K, is said to be *accessible* from a point Y which does not belong to K if there exists a simple continuous arc from X to Y which has no point except X in common with K.

[7] A point-set M is said to be *connected "im kleinen"* if, for every point P of M and every positive number e, there exists a positive number $\delta_{e,p}$ such that if X is a point of M at a distance less than $\delta_{e,p}$ from the point P, then X and P lie together in a connected subset of M every point of which is at a distance of less than e from the point P. The set M is said to be *uniformly* connected *im kleinen* if for every positive number e there exists a positive number δ_e such that if P_1 and P_2 are two points of M at a distance apart less than δ_e then they lie together in a connected subset of M every point of which is at a distance of less than e from P_1. Cf. Hahn, H., *Wien. Ber.*, **123**, 1914 (2433). Hahn shows that in order that a closed, bounded and connected point-set M should be a continuous curve it is necessary and sufficient that M should be connected *im kleinen*. See also, however, Mazurkiewiez, S., *Fundamenta Mathematicae*, **1**, 1920 (166–209). In this article the author refers to earlier articles by himself, published, in 1913 and 1916, in a journal (*C. R. Soc. Sc. Varsovie*) to which I do not, at present, have access.

[8] The point-set t is said to be the limiting set of the sequence of point-sets $t_1, t_2, t_3, \ldots$ provided that (a) each point of t is the sequential limit point of an infinite subsequence of some sequence of points, $P_1, P_2, P_3, \ldots$ sucht hat, for every n, P_n belongs to t_n, and (b) if $P_1, P_2, P_3, \ldots$ is a sequence of points such that, for every n, P_n belongs to t_n then t contains the sequential limit point of every subsequence of $P_1, P_2, P_3, \ldots$ which has a sequential limit point.

CHARACTERISTIC EFFECTS UPON GROWTH, OESTRUS AND OVULATION INDUCED BY THE INTRAPERITONEAL ADMINISTRATION OF FRESH ANTERIOR HYPOPHYSEAL SUBSTANCE *

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At the last session (Proc. Amer. Assoc. Anat., *Anat. Rec.*, vol. 21) we reported a characteristic acceleration of growth in rats treated intraperitoneally with the finely ground, fresh anterior lobe of the hypophysis of beef. We had shown that this effect is in marked contrast to the lack of effects from oral administration of the same substance, even in very large amounts. Two careful series of experiments with litter mate controls have now been completed, some members of the first series having been experimented with continuously for a period of over one year. *Such animals are invariably much heavier than their litter mate sisters.* The greatest disparity which has been observed was attained on the 333rd day of life when an animal receiving anterior hypophyseal substance weighed 596 grams and its healthy litter mate control weighed 248 grams. It would not appear to be incorrect to characterize these changes as producing constantly a certain degree of true gigantism. Increase in weight results to a great extent from a storage of fat, but is not solely due to this, the skeleton being invariably somewhat larger and heavier, and, as would be expected, the heart, lung, alimentary canal and kidney are heavier. The fat deposits in the omentum and mesentery are such that these structures weigh three or four times as much in the experimental animals as in their controls. The weight of the hypophysis, thyroid and thymus is not appreciably effected.

Most surprising is the effect on the reproductive system. *Oestrus, as detected by typical changes in the vaginal smear, may never occur in these animals or may be exhibited only at long intervals.* It was, consequently, surprising to find that in all instances the ovaries instead of being underdeveloped weighed twice as much as they did in the control animals and exhibited great numbers of substantial corpora lutea. The uterus, on the contrary, weighed absolutely about half as much as it did in the normal

controls. Histological examination of the gonads confirmed the presence of very abundant lutein tissue and demonstrated the formation of this tissue about the egg in unruptured, normal follicles and in atretic follicles. Ripe, normal Graafial follicles were invariably absent. *A powerful, specific stimulus to lutein cell transformation has thus been effected by this hormone.*

Aside from the fact that it is tolerated only in smaller quantities, fresh posterior hypophyseal substance gave none of the above characteristic effects upon growth, oestrus and ovulation in animals as compared with similar care with litter mate sisters.

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A STUDY OF THE EFFECTS OF CUCURBITA PEPO SEEDS ON KIDNEY EXCRETION

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1. *Purpose and Plan of Experiment.*—The object of this experiment was to compare and verify the results obtained from a somewhat similar experiment conducted during March 1920.[1] Moreover, a further study of the effects of Cucurbita seeds on kidney excretion is thereby promulgated.

Since the previous experiment does not give sufficient analytical data so far as the urine samples are concerned a more elaborate plan was followed by virtue of which not only comparative data may be obtained but additional analyses may be available for the elucidation of the problem under consideration.

Three successive dietary periods were arranged for the experiment, namely, three days of a preliminary basal dietary period, three days of an experimental dietary period, and three days of a final dietary period. The entire experiment lasted for nine consecutive days.

All the foodstuffs consumed in this experiment were measured. The pumpkin seeds (Cucurbita pepo) were of two kinds, roasted and raw, a known quantity of each kind was added to each meal during the experimental dietary period.

2. *Dietary.*—Hindhede's "back-to-the-farm" dietary,[2] slightly modified, was used for the basal diet. Composition of this dietary is given in table 1. This diet was used during the preliminary and final periods of this experiment. The experimental diet consisted of the same basal diet plus 30 grams of roasted pumpkin seeds for the first day; 35 grams of roasted and 30 grams of raw pumpkin seeds mixed for the second day, and 30 grams of raw seeds for the third day of the experimental dietary period.

TABLE 1

COMPOSITION OF THE BASAL DIETARY[3]

NAME	QUANTITY	PROTEIN	FAT	CARBOHYDRATES	CALORIES
Water	600 cc.				
Graham bread	300 gms.	19.7	4.8	153.9	780
Apples	600 gms.	1.8	3.0	76.8	342
Milk	800 cc.	25.6	30.4	40.0	620
Butter	60 gms.	.6	48.4	...	450
Potatoes	800 gms.	15.2	.8	160.0	800
Total		62.9	87.4	430.7	2992

No salt was used.

3. *Period I.*—In securing the daily samples of urine the bladder was emptied about 7 a. m., April 3rd, and this urine was discarded. All the urine from that hour up to and including that passed the next day at 7 a. m. was saved, thoroughly mixed, preserved with 5 cc. of toluene, a sufficient amount to film the bottom and the walls of the container. The latter were wide mouth glass jars with ground glass stoppers. Thus, each composite sample represented the mixed excretions for twenty-four hours.

As soon as a twenty-four hour sample was secured it was immediately analyzed for the determination of volume, specific gravity, temperature, titratable acidity (using 0.1 *N* NaOH) (4, pp. 508–509), NH_3 determination (Folin's method) (4, p. 523); total nitrogen determination (Kjeldahl method) (4, pp. 512–513); creatinine (Folin's colorimetric method) (4, pp. 530–531); urea (Marshall's method) (4, p. 522); uric acid (Folin and Schaffer method) (4, p. 536); and total solids of a sample were computed by means of Long's coefficient (4, p. 512). The remainder of each of the samples was then covered with a layer of toluene to preserve it for the inorganic analyses.

TABLE 2a

ANALYSES OF COMPOSITE SAMPLES OF URINE FROM PERIOD I

DATE 1921	VOLUME CC.	TEMP. C.	SP. GR.	T. S. GMS.	ACIDITY CC. 0.1 *N* NaOH PER 100 CC.	TOTAL N GMS.
Apr. 3	1360	24	1.019	65.77	39.0	11.72
Apr. 4	1600	22	1.017	66.56	24.3	9.85
Apr. 5	1710	24	1.016	69.35	10.8	10.04

TABLE 2b

NITROGENOUS INGREDIENTS FOUND IN SAMPLES OF URINE, PERIOD I

DATE 1921	AMMONIA	CREATININE	URIC ACID	UREA	UNDETERM. N
Apr. 3	.38	1.07	.57	20.28	1.37
Apr. 4	.48	1.24	.65	17.17	.78
Apr. 5	.31	1.28	.73	18.54	.39

4. *Period II.*—The pumpkin seeds used during this experiment were obtained from a seed grower. The roasting was done after the hulls were removed. The hull-free seeds were placed in a flat glass dish and kept in a dry-heat oven for three hours at a temperature of 110° F. or 43° C.

The table below shows the quantities of pumpkin seeds ingested at each meal during the experimental Period II.

KIND	APRIL 6 BREAKF. GMS.	APRIL 6 LUNCH GMS.	APRIL 6 DIN. GMS.	APRIL 7 BREAKF. GMS.	APRIL 7 LUNCH GMS.	APRIL 7 DIN. GMS.	APRIL 8 BREAKF. GMS.	APRIL 8 LUNCH GMS.	APRIL 8 DIN. GMS.
Roasted	5	10	15	15	15	5	..	..	.
Raw p. s.	.	..	..	5	10	15	15	10	5

The same methods of sampling and analyzing employed in Period I were also used in Period II of this experiment.

TABLE 3*a*

ANALYSES OF COMPOSITE SAMPLES OF URINE FROM PERIOD II

DATE 1921	VOLUME CC.	TEMP. C.	SP. GR.	T. S. GMS.	ACIDITY CC. 0.1 *N* NaOH PER 100 CC.	TOTAL N GMS.
Apr. 6	1425	20	1.019	64.46	17.8	9.69
Apr. 7	1945	19	1.013	55.62	15.1	10.14
Apr. 8	2150	22	1.014	72.67	14.2	12.08

TABLE 3*b*

NITROGENOUS INGREDIENTS FOUND IN SAMPLES OF URINE FROM PERIOD II

DATE 1921	AMMONIA	CREATININE	URIC ACID	UREA	UNDETERM. N
Apr. 6	.41	.79	.74	17.69	.58
Apr. 7	.44	1.01	.79	17.88	.76
Apr. 8	.56	1.34	.85	20.61	1.19

5. *Period III.*—During the final three days, April 9, 10, 11, of this experiment the diet was exactly the same as during the preliminary Period I.

TABLE 4*a*

ANALYSES OF COMPOSITE SAMPLES OF URINE FROM PERIOD III

DATE 1921	VOLUME CC.	TEMP C.	SP GR	T. S. GMS.	ACIDITY CC. 0.1 *N* NaOH PER 100 CC.	TOTAL N GMS.
Apr. 9	1705	22	1.016	66.49	20.5	10.16
Apr. 10	2370	17	1.015	76.40	7.5	9.70
Apr. 11	1910	18	1.016	67.53	12.8	9.45

TABLE 4*b*

NITROGENOUS INGREDIENTS FOUND IN SAMPLES OF URINE, PERIOD III

DATE 1921	AMMONIA	CREATININE	URIC ACID	UREA	UNDETERM. N
Apr. 9	.53	1.18	.62	16.58	1.37
Apr. 10	.55	1.35	.63	17.26	.49
Apr. 11	.50	1.32	.66	15.63	1.04

6. *Discussion.*—To reduce the effect of the variation factor upon the study of results and to obtain a more satisfactory comparison the hypothetical mean of results of each period was computed.

The following table V presents the data for comparison.

TABLE 5

COMPARATIVE RESULTS FOUND DURING PERIODS I, II AND III
(HYPOTHETICAL MEANS)

PERIOD	VOLUME CC.	T. S. GMS.	ACIDITY CC. 0.1 *N* NaOH	T. N. GMS.	NH_3 GMS.	CREATININE GMS.	URIC ACID, GMS.	UREA GMS.
I	1655	67.95	17.5	9.94	.39	1.26	.69	17.85
II	2047	64.14	14.6	11.11	.50	1.17	.82	19.24
III	2140	71.96	10.15	9.57	.52	1.33	.64	16.44

From this table we find that the average daily output of urine during Period II was greater than that of Period I but smaller when compared with the average daily volume of urine excreted during Period III.*

The amount of total solids of the experimental Period II was less as compared with either of the basal periods (I and II) which served as a check in this work. The acidity of the urine excreted during Period II was on the average slightly greater than that of Period III which agrees with the results obtained in the first experiment.[1]

The total nitrogen output is highest in Period II due to the fact that additional feeding substances, in the form of pumpkin seeds, were added to the basal diet.

Of the nitrogenous ingredients of the average samples of the three periods, uric acid of Period II shows a marked relation to that of Periods I and III. Namely, taking the average quantity of uric acid excreted during Period III as 100%, we find that the average output of uric acid during Period II was 128.12%.

Creatinine of the average sample of urine excreted during Period II as compared to that of Period III is as 100% is to 87.97%. The excretion of urea during Period II was 117%.

A comparative qualitative test (Obermayer's) for indican of all the nine samples of urine gave the results shown in table 6 below:

TABLE 6

COMPARATIVE INDICAN CONTENT

SAMPLE NO.	GRAPHIC REPRESENTATION	RANK ACCORDING TO INTENSITY OF COLOR
1	******	4th place
2	***	7th place
3	**	8th place
4	****	6th place
5	********	3rd place
6	**********	1st place
7	*********	2nd place
8	*****	5th place
9	*	9th place

It is of significant interest to note that the last two samples of the experimental period and the first sample of the final period gave the deepest coloration when tested for indican.

7. *Inorganic Determinations.*—For the determination of total sulphates and ethereal sulphates Folin's methods were employed; total phosphates were determined by the Uranium Acetate method; for the determination of chlorides and chlorin Volhard-Arnold method was employed.

TABLE 7

MINERAL INGREDIENTS FOUND IN THE URINE SAMPLES, GMS.

SAMPLE NO.	CHLORIDES	Cl	TOTAL P_2O_5	TOTAL SO_3	ETHEREAL SO_3
1	9.05	5.43	1.67	1.57	.268
2	8.66	5.20	1.56	1.60	.367
3	7.42	4.45	1.69	1.64	.328
4.6	6.61	3.96	1.71	1.76	.332
5	6.51	3.90	1.87	1.78	.346
6	7.86	4.72	2.08	1.97	.426
7	6.83	4.10	1.73	1.70	.331
8	7.77	4.66	3.14	1.83	.299
9	7.28	4.39	1.74	1.83	.288

8. *Conclusions.*—I. The results obtained in the experiment substantiate the results of the first experiment inasmuch as the volume and total solids output during the experimental Period II was less than in the check Period III; the hypothetical volume for the check period being 2140 cc. while during the experimental Period II the output was 2047 cc.; the average output of total solids during the check period being 71.96 while during the experimental Period II it was 64.14 gms.

II. There was 28.12% more uric acid eliminated during Period II than during the check Period III.

III. Also 17% more urea was eliminated during the experimental period than during the check Period III.

IV. The striking difference in the intensity of color in the urine samples of the experimental period revealed by the indican test is of pathological significance.

V. From the verified results and additional data obtained in this experiment the rôle played by Cucurbita pepo seeds in animal metabolism is of a chemico-pharmacognostic value.

I wish to express my thanks to Prof. W. J. Gies (Columbia) and Dr. E. G. Miller, Jr. (Columbia), for helpful suggestions in this work and to Dr. J. G. Lipman, Director of N. J. Agr. Exp. Station, for material assistance with this experiment.

* For the sake of uniformity in this work the mean of only the second and third days' results of each period was taken. For it is evident that the first day's excretions are only slightly affected by the change of diet.

[1] Masurovsky, B., "Effects of Some Cucurbita Seeds on Animal Metabolism," *J. Agric. Res.*, **21**, No. 8, 1921 (523).

[2] Lusk, G., *Science of Nutrition*, p. 340.

[3] Atwater and Bryant, "The Chemical Composition of American Food Materials," *Bull.* **28** (Revised), *U. S. Dept. of Agriculture*, 1902.

[4] Hawk, P. B., *Practical Physiological Chemistry*, 6th edition, 7 pl. (col.), 1920.

THE ACTION OF DIAZOMETHANE ON URACIL

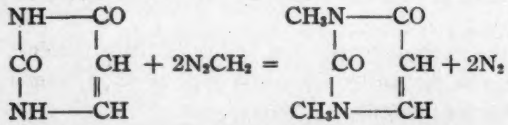
By Treat B. Johnson, Arthur J. Hill and Francis H. Case

Department of Chemistry, Yale University

Communicated Jan. 25, 1922

In the course of work now in progress on the determination of constitution of nucleic acid and its primary hydrolytic products—neucleotides and neucleosides—it has finally become necessary to develop and utilize a new method for introducing methyl radicals into pyrimidine and purine combinations. The alkylation methods generally employed for bringing about such changes, namely, by interaction of alkali or silver salts with methyl iodide and dimethyl sulphate, have not proven satisfactory, and it has become necessary to turn to a reagent that will interact directly with the pyrimidine nucleus at a low temperature and in other solvents than water or alcohol. A reagent which has found little use thus far in biochemical research and which gives promise of proving extremely helpful in the solution of our problem is the very reactive aliphatic reagent, diazomethane:

We now find that pyrimidines of the type of uracil interact smoothly with this reagent in ether solution at ordinary temperature. The reaction is productive of nitrogen-alkyl derivatives and in the case of the pyrimidine uracil leads to the formation of 1,3-dimethyluracil in good yield. The interaction of uracil and diazomethane may be expressed, therefore, as follows:



The reaction in question is applied by suspending dry, pulverized uracil in dry ether containing an excess (4–6 moles) of diazomethane and allowing the mixture to stand at ordinary temperature until the uracil completely dissolves. The reaction is complete in about 4 days when working with uracil in units of one gram. The dimethyl uracil is obtained in the form of slender colorless prisms which melt at 121.5° C. (Nitrogen determination: calculated, 20.03%; found, 19.87%.)

The study of the behavior of thymine and cytosine is now in progress. The results thus far obtained by alkylation with this reagent indicate that we may be able to use it with success for the detection of replaceable hydrogens in the more complicated pyrimidine and purine glucosides.

Where CO.NH groupings functionate in such constructions it should be possible to replace hydrogen in such amide groupings with methyl by action of this reagent. The hydrolysis of the products of alkylation should lead to the formation of methyl derivatives of known constitution, thereby contributing new knowledge regarding the constitution of the parent substances. The final results of our researches will be published in the *Journal of the American Chemical Society.*

ABSORPTION OF SHORT X-RAYS BY ALUMINIUM AND COPPER

BY WILLIAM DUANE AND K. C. MAZUMDER

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Communicated, February 1, 1922

1. In 1914 one of us presented to the American Roentgen Ray Society and to the American Physical Society descriptions of methods of measuring the average or "effective" wave-length of a beam of X-rays, without the use of an X-ray spectrometer. Mr. Hunt and one of us[1] have shown that even if a constant voltage (from a storage battery, for instance) drives a current through an X-ray tube the resulting X-rays are not monochromatic but contain X-rays covering a considerable range in the spectrum, that depends upon the absorption of the matter through which the rays pass, as well as upon the voltage applied. We define the term "effective" wave-length to mean the wave-length that has the same absorption in a given case as that of the whole beam. For many purposes this "effective" wave-length appears to be an important wave-length to know. The methods of estimating it described in 1914 were based upon a measurement of the absorption of the beam of X-rays in aluminium or copper and the determination of the wave-length from a curve giving the relation between the absorption of monochromatic X-rays and their wave-lengths. Curves were drawn from all the data available at the time representing this relation. It was proved that over a very wide range of wave-lengths, namely, from about 3 ångströms down to .35 of an ångström, the relation between the mass coefficients of absorption and the wave-lengths could be reasonably well represented by the equation

$$\frac{\mu}{\rho} = 14.9\,\lambda^3, \qquad (1)$$

where $\frac{\mu}{\rho}$ is the total mass coefficient of absorption and λ is the wave-length in ångströms.

Since 1914 Hull and Rice[2] and Richtmyer[3] have measured the coefficients of absorption in aluminium and copper for wave-lengths lying between .75 and .135. They find that the relation between the mass co-

efficient of absorption and the wave-length may be expressed approximately by an equation of the form

$$\frac{\mu}{\rho} = k\lambda^3 + s. \qquad (2)$$

Hull and Rice give for the constants k and s: $k=14.9$ and $s=.12$ for aluminium; and $k=150$ and $s=.12$ for copper, the range of wave-lengths lying between .392 and .147.

Richtmyer gives the following values for the constants k and s: for aluminium $k=14.5$ or 14.3 and $s=.15$ or .16; and for copper $k=147$ and $s=.5$.

2. As a great deal of work is now being done on X-rays of wave-lengths shorter than .135, we have undertaken to extend the measurements of the absorption in aluminium and copper to cover the range of these shorter waves. We have measured the mass coefficients of absorption for aluminium and copper for wave-lengths from .165 to .095.

In making these measurements we have used a Coolidge X-ray tube with a Tungsten target, excited by the high tension, constant voltage generating plant that has been described elsewhere. The constant voltage employed for these short waves amounted to about 160,000 volts. The X-ray spectrometer employed has been described also, together with the methods of protecting it against stray radiation, etc. This protection against stray radiation becomes of very great importance for the shorter, penetrating rays. It is sufficient to call attention to the fact that the X-ray tube with its generating plant was in one room and the spectrometer in an adjoining room, and that thick lead plates were fastened to the wall between the two rooms for additional protection. Further, the entire spectrometer was in a zinc box that completely surrounded it.

3. In making measurements of the coefficients of absorption we set the spectrometer to reflect a given wave-length into its ionization chamber. We then measure the ionization current with a plate of the absorbing substance placed between the X-ray tube and the hole in the wall through which the X-rays pass to the spectrometer. We next measure the ionization current with this plate removed. From each of these currents must be subtracted the current due to scattered radiation and to the natural leak in the instrument. This correction we estimate by turning the crystal of the spectrometer into such a position that it does not reflect rays into the ionization chamber, and measuring the ionization currents both with and without the absorbing plate in place. Subtracting the correction currents from the currents obtained with the crystal in its proper position, we get the fraction of radiation passing through the absorbing substance, and from this we calculate the mass coefficient of absorption in the usual way.

Aluminium plates of density 2.70 and plates of pure copper of density 8.92 were employed.

The following table contains the data obtained:

λ	$\frac{\mu}{\rho}$	
	ALUMINIUM	COPPER
.1653	.218	1.015
.1477	.194	.745
.1381	.189	.631
.1290	.182	.538
.1124	.167	.399
.0951	.161	.299

Our data agree very well with the values obtained by Richtmyer for wave-length .135.

4. In the figure we have plotted the mass coefficients against the cubes of the wave-lengths. Points marked (+) represent our measurements. Those marked (⊙) represent Richtmyer's data.

It appears that neither curve should be regarded as strictly a straight line. Both curves bend downward in the region of the shorter wave-lengths. Owing to this curvature it is impossible to estimate with certainty the points at which the curves strike the axis of zero wave-length. Extrapolations of this kind may lead to quite erroneous conclusions. The curves, however, appear to be pointing toward the values .146 for aluminium and .13 for copper at zero wave-length.

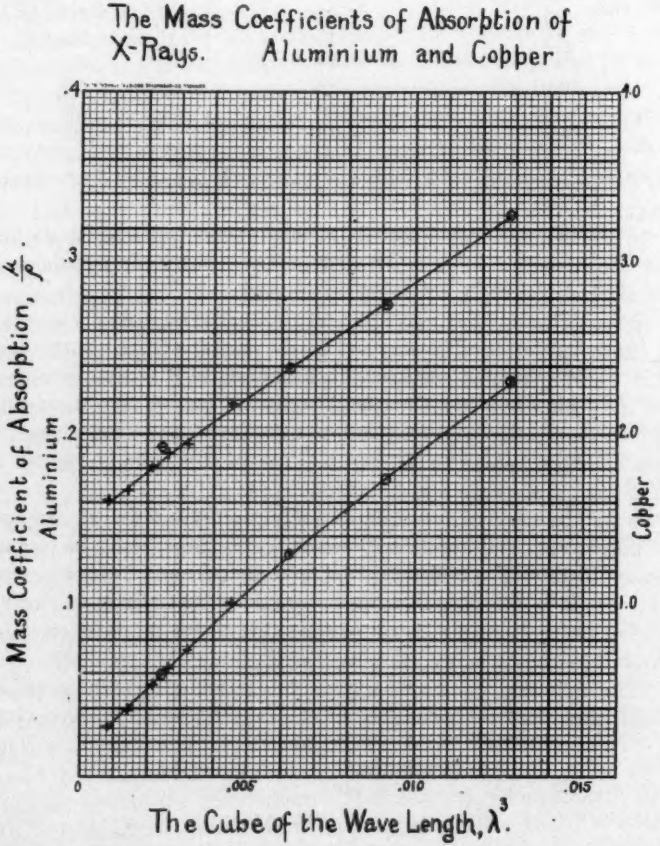
According to the usual method of analyzing coefficients of absorption into fluorescent and scattering coefficients these may be regarded as mass scattering coefficients for aluminium and copper, respectively. It is quite possible, however, that, according to some of the recent conceptions of absorption, this division of the coefficients into fluorescent and scattering coefficients may be somewhat artificial.

5. The following equations represent approximately the coefficients of absorption that we measured in the region of short wave-lengths:

$$\text{For aluminium } \frac{\mu}{\rho} = 15.5\,\lambda^3 + .147$$
$$\text{For copper } \frac{\mu}{\rho} = 193\,\lambda^3 + .13 \qquad (3)$$

It will be noticed that the mass scattering coefficient for aluminium does not differ appreciably from that obtained by Richtmyer, and that the mass scattering coefficient for copper agrees well with that given by Hull and Rice. The coefficients of the terms containing the cube of the wave-length, however, are each larger than the corresponding quantities deduced by Hull and Rice and Richtmyer from their experiments on longer waves.

6. Evidently by means of the relation between the absorption and the wave-length it becomes possible in any practical case to determine the "effective" wave-length for a beam of X-rays by simply measuring the fraction of the radiation that passes through a plate of aluminium or a plate of copper. The details of such experiments will be given elsewhere. It is sufficient to note here that owing to the rapid change of absorption



with wave-length, copper should be used for estimating the wave-length of short rays, whereas aluminium is better for longer ones.

In certain practical cases (in radio-therapy, for instance) another method of estimating the "effective" wave-length appears to be preferable. This consists in determining by means of an ionization chamber, a photographic plate or a fluorescent screen the thickness of aluminium that is

equivalent to a given thickness of copper. The ratio of the equivalent thicknesses of aluminium and copper changes a great deal in this short wave-length region of the X-ray spectrum. In the neighborhood of wave-length .3, for instance, an aluminium plate must be twenty-eight times as thick as a copper plate in order to absorb the same fraction of X-radiation. For wave-length .095, however, a plate of aluminium only 6 times as thick as a plate of copper will absorb the same fraction of X-radiation. The estimate of the equivalent thickness of aluminium and copper can be made comparatively easily and rapidly, so that the method furnishes a good means of determining the "effective" wave-length of a beam of X-rays during a treatment with them.

The curve giving the relation between the equivalent thickness and the wave-length will be published in a technical journal. The equivalent thickness for a given short wave-length can be calculated, of course, from equations (3), by dividing the linear coefficient of absorption for copper by that for aluminium.

The coefficient of absorption of a beam of rays that is not monochromatic usually (but not always) decreases as the rays pass through matter. If one measures the coefficient of absorption of such a beam, the results give a kind of average coefficient of absorption for the rays, as they travel through the absorbing material. Similarly, the above-mentioned methods of measuring the "effective" wave-lengths furnish a kind of average value for the "effective" wave-length of the beam as the rays pass through the plates.

[1] *Ithaca, Physic. Rev.*, August 1915, p. 166.
[2] *Ibid.*, Sept. 1916, p. 326.
[3] *Ibid.*, July 1921, p. 13.

THE EFFECTIVE TEMPERATURE OF 16 STARS AS ESTIMATED FROM THE ENERGY DISTRIBUTION IN THE COMPLETE SPECTRUM

By W. W. Coblentz
Bureau of Standards, Washington, D. C.
Communicated by V. M. Slipher, January 23, 1922

1. *Introductory Statement.*—Data on the spectral energy distribution of stars as related to that of a black body are very meager. They are the results practically of the spectrophotometric measurements of Wilsing,[1] and of Nordmann,[2] and the spectral energy curves determined photographically by Plaskett,[3] all of which relate to the visible spectrum.

The various methods used to obtain stellar temperatures give different results. For example, Plaskett (loc. cit.) obtained an effective temperature of 6800° K for γ *Cassiopeiae* (Class Bop) by considering the continuous spectrum and 10,600° K by considering the bright line spectrum.

In view of the fact that his continuous spectrum measurements terminated at 0.42 μ, where also is the observed maximum spectral energy, it is possible that the higher estimated temperature is the more nearly correct.

Wilsing, Scheiner and Münch (loc. cit.) also obtained a temperature of 6800° K for γ *Cassiopeiae*. Their temperature measurements of various stars of class *B* vary from 7000° to 15,000° K; class *A*, from 8000° to 12,000° K; class *F* from 5000 to 7000° K; class *G*, from 4000 to 5000° K; and class *M*, 3000° to 3500° K.

While it is to be expected that the various methods must give different results, it is interesting to find a rather close agreement in the estimated stellar temperatures. The agreement is especially close for stars of classes *G*, *K* and *M*, that is, stars having a low temperature.

In a previous paper,[4] data were given on a comparison of stellar radiometers and radiometric measurements of 110 stars using the Crossley reflector of the Lick Observatory at Mt. Hamilton, Calif., the altitude being about 4000 ft. Quantitative measurements were made on stars down to magnitude 5.3, and qualitative measurements to magnitude 6.7. It was found that red stars emit from 2.5 to 3 times as much *total* radiation as blue stars of the same visual magnitude.

These observations were verified by an independent method which consisted in measuring the transmission of stellar radiation through a 1-cm. cell of water, having quartz windows. By this means it was shown that of the *total* radiation emitted, blue stars have about 2 times as much *visible* radiation as yellow stars and about 3 times as much *visible* radiation as red stars.

2. *Experimental Procedure.*—In the present investigation the spectral energy distribution of a star was determined by means of a series of transmission screens, placed in front of a vacuum thermocouple which was used as the radiometer.

Screens were selected which, either singly or in combination, had a uniformly high transmission over a fairly narrow region of the spectrum terminating abruptly in complete opacity in the rest of the spectrum. By proceeding in this manner the observations required no correction other than that for surface reflection, which amounts to about 9 per cent for the two surfaces of the screen. Corrections were made for absorption by the telescope mirrors, also for atmospheric absorption, using the spectral transmission factors for the sun, as observed by Abbot and Fowle.

By means of these screens (of red and yellow glass, quartz and water) it was possible to obtain the radiation intensity in the spectrum (from the extreme ultra-violet, which is limited by atmospheric transmission and the low reflectivity of the telescope mirrors) at 0.3μ to 0.43μ; 0.43μ to 0.60μ; 0.60μ to 1.4μ; 1.4μ to 4.1μ; and 4.1μ to 10μ.

In this manner the distribution of energy in the spectra of 16 stars was

determined, thus obtaining for the first time an insight into the radiation intensities in the complete spectrum of a star.

3. *Results.*—By means of this device it was found that, in the class *B* and class *A* stars, the maximum radiation intensity lies in the ultra-violet (0.3μ to 0.4μ) while in the cooler, classes *K* and *M*, stars, the maximum emission lies at 0.7μ to 0.9μ in the infra-red. From this it appears that the black body temperature (i.e., the temperature which a black body would have to attain in order to emit a similar relative spectral energy distribution) varies from 3000° C for red, class *M*, stars to 10,000° for blue, class *B*, stars.

This estimate of the effective temperature of a star was obtained by two methods. The first method consisted in making all corrections to the observations, excepting those for atmospheric absorption, and comparing them with the calculated values, using a solar type star (α Aurigae, class *Go*) as a standard. This seems permissible, in view of the fact that the observed temperature (6000° K) of α Aurigae was found to be in close agreement with that assigned to the sun. The stellar temperatures estimated in this manner are given in column 4 of table 1.

The second method consisted in applying all corrections to the observations, including the one for atmospheric absorption, and comparing the results with the calculated values. Applying factors for atmospheric absorption introduces great irregularities in the observed spectral radiation components. This, no doubt, is owing partly to selective emission of the star, and partly to the use of improper transmission factors, which, because of lack of time, could not be determined directly.

The temperature of a star, as estimated from the spectral energy components outside of the atmosphere, extends over a wide range, the average value of which is in good agreement with that obtained by the first method (see column 3 of table 1).

In table 1 are assembled the effective stellar temperatures as determined by various methods. The agreement is especially close for stars of classes *G*, *K* and *M*.

Most of the stars measured are no doubt giants, of which Russell[5] says: "The mean densities of the giant stars diminish rapidly with increasing redness, from one-tenth that of the sun for class *A* to less than one-twenty-thousandth that of the sun for class *M*." In speculating on the nature of stellar radiation and stellar temperatures it is interesting to find that the observed radiometric data (see table 2) seem conclusive in showing that the early type (class *M*) stars are losing heat 3 to 4 times as fast as the more dense, but hotter late-type (class *B*, *A*) stars. The least dense, class *M*, stars must therefore be losing heat by radiation, in which conduction cannot contribute very materially in maintaining the surface at a given temperature.

In the dense stars the shape of the spectral energy curve, and hence our inference of the effective temperature is determined by the spectral emissivity of the surface; while in the less dense stars the radiation emanates from great depths.

TABLE 1

STELLAR TEMPERATURES

STAR	CLASS	COBLENTZ		WILSING, SCHEINER & MÜNCH	NORDMANN & LEMORVAN	NORDMANN
		Calculated	Class *Go* as Standard			
ϵ Orionis	Bo	13000 to 14000° K	13000° K			
β Orionis	B8p	10000 to 12000	10000			
α Lyrae	Ao	8000 to 10000	8000	9400° K		12200° K
α Canis Majoris	Ao	8000 to 11000	8000			
α Cygnii	A2	8000 to 10000	9000	9400		
α Aquilae	A5	7000 to 9000	8000	8100		
α Canis Minoris	F5	5500 to 7500	6000	7200		
α Aurigae	Go	5300 to 6500	6000	7100		
α Boötis	Ko	3500 to 4500	4000	3700		
β Geminorum	Ko	4500 to 7000	5500	4900		
α Tauri	K5	2800 to 4500	3500	3500	3600	3500
α Orionis	Ma	2800 to 3300	3000	3000		
α Scorpii	Map	2500 to 3200	3000			

β Andromedae	Ma	3500 to 4500	4000	3200	4300	3700
μ Geminorum	Ma	2500 to 3300	3500	3100	3200	
β Pegasi	Mb	2500 to 3200	3000	2800		
Sun	Go		5800* to 6200			5320

* Recalculated from Abbot & Fowle, *J. Opt. Soc. Am.*, **5**, 1921 (272).

Through the generosity of Drs. V. M. Slipher and C. O. Lampland, the present data were obtained during the past summer, using the 40-inch reflector of the Lowell Observatory, at Flagstaff, Arizona, altitude 73,000 ft. Dr. Lampland personally operated the telescope, thus insuring speed and efficiency. It is a pleasure to record here my grateful acknowledgment for the many courtesies extended me by various members of the Observatory Staff.

TABLE 2

COMPARISON OF THE TOTAL RADIATION FROM STARS HAVING CLOSELY THE SAME VISUAL MAGNITUDE

STAR	SPECTRAL CLASS	VISUAL MAGNITUDE	GALVANOMETER DEFLECTION CM.
ε Geminorum	G5	3.18	0.58
μ Geminorum	Ma	3.19	2.11
β Geminorum	Ko	1.21	2.19
α Scorpii	Map	1.22	8.82
α Aquilae	A5	0.90	1.89
α Tauri	K5	1.06	6.03
α Orionis	Ma	0.92	15.0
ρ Ophiuchi	Ko	2.94	0.37
δ Ophiuchi	Ma	3.03	1.37
γ Leonis	Ko	2.61	0.99
β Pegasi	Mb	2.61	2.96
α Coronae Borealis	Ao	2.32	0.48
β Ursa Majoris	Ao	2.44	0.37
γ Draconis	K5	2.42	1.65
α Aurigae	Go	0.21	4.91
α Boötis	Ko	0.24	8.10

[1] Wilsing, Scheiner and Münch, *Publ. Astrophys. Obs., Potsdam*, **24**, 1920 (No. 74).

[2] Nordmann, Paris, *Compt. Rend.*, **149**, 1009 (1038). Nordmann and LeMorvan, *Ibid.*, **173**, 1921 (62).

[3] Plaskett, *Mon. Not. R. A. S.*, **80**, 1920 (771).

[4] Coblentz, *Washington, Bur. Standards, Bull.* **11**, 1914 (613).

[5] Russell, *Pop. Astron.*, **22**, Nos. 5 and 6, 1914.

ADDITIONAL STUDIES IN ARRESTED EVOLUTION

BY RUDOLPH RUEDEMANN

STATE MUSEUM, ALBANY, N. Y.

Communicated by J. M. Clarke, January 29, 1922

In a former paper on the "Palaeontology of Arrested Evolution,"[1] the writer has traced the causes of *persistence* in animals as seen from the viewpoint of the palaeontologist.

A number of conclusions as to the distribution of persistent types in the different classes and as to the probable causes of persistence were there obtained by a statistical method, in which the genera persisting through more than two geological periods were utilized. Two entirely different groups of such persistent genera were distinguished and these were termed *persistent radicles* and *persistent terminals*. The former are primitive central stocks, still adapted to a variety of conditions; the latter post-climacteric types which have become fixed in their characters by having found stable physical surroundings, or by gerontic conditions, loss of variability, etc.

In continuation of these studies the writer has investigated the possible influence recorded in fossils, of the different modes of propagation upon the persistence of types and has found that all the lower modes of propagation, viz., propagation by simple division, by budding, by her maphrodites and by parthenogenesis, are distinctly favorable to persistence, mainly through diminution in the frequency and range of variability as far as it is induced by fertilization.

In trying to trace the persistence of types to its ultimate causes, beyond the processes of heredity, ontogeny, environment and selection, around which the life and evolution of animals may be said, with H. F. Osborn. to center, it was found that the process of selection may account for the cases of persistence where variability has been reduced to a minimum by the modes of propagation mentioned before; and that environment accounts for resistance in those cases where it has become so stable as to lack the actual stimulus for further development or change of form. But it is obvious that there are still more important factors involved in heredity and ontogeny that make for persistence in organisms, especially as that is shown in the post-climacteric forms, or persistent terminals. And above all, none of the four factors, selection, environment, heredity and ontogeny, gives any clue to the actual mechanics of the processes that induce persistence in types.

Such explanation of persistent types and a clue to the mechanics of the processes involved is intimated in the views recently advanced on the methods of inheritance and production of new characters by means of the genes or character-determiners of the heredity-chromatin. Dürken and

Saalfeld[2] hold that external influences act first upon the cytoplasm (protoplasm) of the cells, and especially of the germ-cells, producing inceptive genes (plasmogenes) which finally become true genes of the heredity-chromatin when the long-continued strain has passed a certain "threshold." This final abrupt change would well account for the abrupt appearance of new characters in the ontogeny, or the salto-mutations of De Vries and the constancy of persistent types under stable external conditions. Likewise the fact that the cytoplasm is known to influence the heredity-chromatin of the nucleus, or the genes, would explain the absence of fluctomutations or variations under stable conditions. Persistent types are then either forms in which through lack of external stimulation no changes arise in the cytoplasm that produce new genes; that is, forms in which the cytoplasm is not able to react any more to external influences and differentiation could take place only through loss of genes or a combinative mode of production of new genes. This latter method leads to so-called "self-differentiation" and thereby to the excessive terminal forms of series, or to terminal persistent types, in which latter case absolute rigidity of the forms would result from the entire failure of acquisition of new genes and gerontic rigidity in the old ones.

The persistent radicles, on the other hand, correspond to the extreme development of what Saalfeld, from his studies of ammonites, terms "Konservativreihen." These are series in which the salto-mutations appear in very long intervals, while the numerous side-branches (which furnish the index-fossils) develop by rapid salto-mutations. These persistent radicles are therefore able to undergo new periods of explosive and climacteric development (Virenz-perioden of Wedekind) and are thus still less absolutely persistent than the persistent terminals.

[1] Presidential address before The Palaeontological Society, Albany meeting 1916, *N. Y. State Mus., Bull.* **196**, 1918 (107–38).

[2] *Die Phylogenes Fragestellungen zu ihrer exakten Erforschung. Berlin. Gebr. Bornträger.* 1921.

NEW FORMS OF LIFE FROM THE SILURIAN

BY RUDOLPH RUEDEMANN

STATE MUSEUM, ALBANY, N. Y.

Communicated by J. M. Clarke, January 29, 1922

The silurian of New York (Bertie waterlime and Lockport limestone) have recently yielded some extraordinary fossils which are now under investigation.

There are algae with well-preserved air-bladders, and primitive land-plants with thick coaly tissue. The graptolites, however, are the most striking: Dictyonemas, a foot and more in diameter, and varied types of the Inocaulis group. The latter possess thickly sheathed, glove-finger

like basal tubes that served as anchors, with distal or upper extremities, confused masses of long, rigid or flexed thecae giving the part the appearance of a Medusa-head. By frequent division into bundles of thinner tubes, these thecae sometimes produce a still denser mass, in which the axis is a compound, spirally rising platform composed of broader thecae. In this respect the structure is identical in appearance with the graptolite genus Cactograptus.

Worms abound in certain beds of both the formations named, several entire individuals with distinct segmentation having been found, one clearly referable to Protoscolex.

Among the brachiopods a species of Lingula preserves the original concentric color-bands.

Most interesting among the cephalopods is a Hexameroceras, in which the sides of the slit leading to the hyponomic sinus are provided with interlocking teeth, serving for protection, as in the case of the narrow slit-like aperture of the living Cypraea and other gastropods. This and other observations made upon these Silurian cephalopods are significant as supporting the view lately advanced by Prell (*Centralblatt*, No. 10, 1921, pp. 303–315) that in the early nautiloids of the Phragmoceras and Gomphoceras types with variable and contracted apertures, the animals lacked all cartilaginous cephalic parts and were so plastic that they were able to squeeze their entire cephalopodium out; thus comparable to the recent Helix and Cypraea. The apertural sinuses which have served to distinguish the so-called genera Pentameroceras, Hexameroceras, etc., are therefore not as constant features as has been supposed, nor did they serve as exits for arms.